Hetch Hetchy Reservoir Quadrangle, Yosemite National Park, California–Analytic Data

GEOLOGICAL SURVEY PROFESSIONAL PAPER 774–B

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By RONALD W. KISTLER

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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Chemical, spectrographic, and modal analyses and potassium-argon age determinations on granitic rocks supplement Geologic Quadrangle Map GQ–1112

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By RONALD W. KISTLER

ABSTRACT

Modal analyses of 226 samples and chemical analyses of 27 samples of granitic rocks show that the average compositions of individual plutons range from quartz diorite to alaskite. Potassium-argon analyses of biotite and hornblende separates from specimens of two granitic rocks yield ages in the range of 82–96 million years.

INTRODUCTION

The data in this paper are for use with the "Geologic map of Hetch Hetchy quadrangle, Yosemite National Park, California", U.S. Geological Survey Map GQ–1112 (Kistler, 1973). The Hetch Hetchy quadrangle encompasses about 240 square miles in the center of Yosemite National Park. A single road, California State Highway 120, traverses the central part of the area. The major topographic feature in the quadrangle is the Grand Canyon of the Tuolumne River, which ranges in elevation from a little less than 4,000 feet along the river to more than 9,000 feet along the canyon rim. A dense forest, mainly on thick till and moraines deposited by ancient glaciers, covers about one-half of the quadrangle.

F. C. Calkins (1930) published a geologic map of part of the Yosemite Valley region that includes the southeast corner of the quadrangle. Calkins assigned relative ages to the granitic formations and described their petrology. F. E. Matthes (1930) discussed the glaciology of the Yosemite region and described in detail the tills and moraines along Yosemite Creek in the south-central part of the Hetch Hetchy quadrangle. The present mapping and geologic study extend the pioneering work of these men and is part of a continuing series of geologic investigations of bedrock geology of the central Sierra Nevada batholith (Bateman and others, 1963).

BEDROCK UNITS

Twelve major granitic formations ranging in composition from quartz diorite to alaskite constitute more than 95 percent of the bedrock in the quadrangle (fig. 1). Intrusive relations observed in the field and potassium-argon and rubidium-strontium dating (Curtis and others, 1958; Evernden and Kistler, 1970; this report) made it possible to assign these formations to three age groups. The early Cretaceous group is represented by a single unit of quartz diorite. In each of the Late Jurassic and Late Cretaceous groups, the oldest formation is quartz diorite, and the youngest is alaskite or aplite.

The oldest rocks of the quadrangle are marble, biotite-muscovite schist, and quartzite in small roof pendants. These rocks, of probable Paleozoic age, are complexly deformed and metamorphosed to hornblende hornfels facies. Volcanic mudflows and a trachyandesite flow of Miocene(?) and Pliocene age occur in isolated exposures to the north of the Grand Canyon of the Tuolumne River. A specimen of trachyandesite from Rancheria Mountain has been dated as 9 million years old (Pliocene) by the potassium-argon technique (Dalrymple, 1963).

ANALYTIC DATA

The specific gravity and modal composition of 226 samples of granitic rock were determined. Modal analysis permits the volume percentage of the major minerals of a granitic rock (quartz, potassium feldspar, plagioclase, and mafic minerals) to be calculated by determining the mineral constituent present at each of 1,000–2,000 regularly spaced points on a sawed stained slab of the sample. The volume percentage of each mineral species is shown for each sample locality on the simplified bedrock map of the quadrangle in figures 2–5. The percentages were contoured by visual inspection to show the compositional patterns for each mineral. Specific gravities are shown in figure 6.

Chemical analyses by the rapid method of Shapiro and Brannock (1962) were made of 27 representative samples from 11 of the granitic units and of a single trachyandesite sample. Potassium-argon ages of biotite and hornblende separated from samples of two of the granitic rocks were determined. The locations of the chemically analyzed and the dated samples are shown in figure 1. The chemical data, together with semiquantitative spectrographic analyses and CIPW norms, are given on table 1. The analytical data used in the age determinations are given on table 2.

Modes of the granitic rocks, recalculated to 100 percent, are plotted on triangular diagrams whose corners are quartz, plagioclase, and potassium feldspar in figure 7. In the same figure, norms of the chemically analyzed samples are plotted on triangular diagrams whose corners are normative quartz, plagioclase (albite plus anorthite), and orthoclase.

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FIGURES AND TABLES

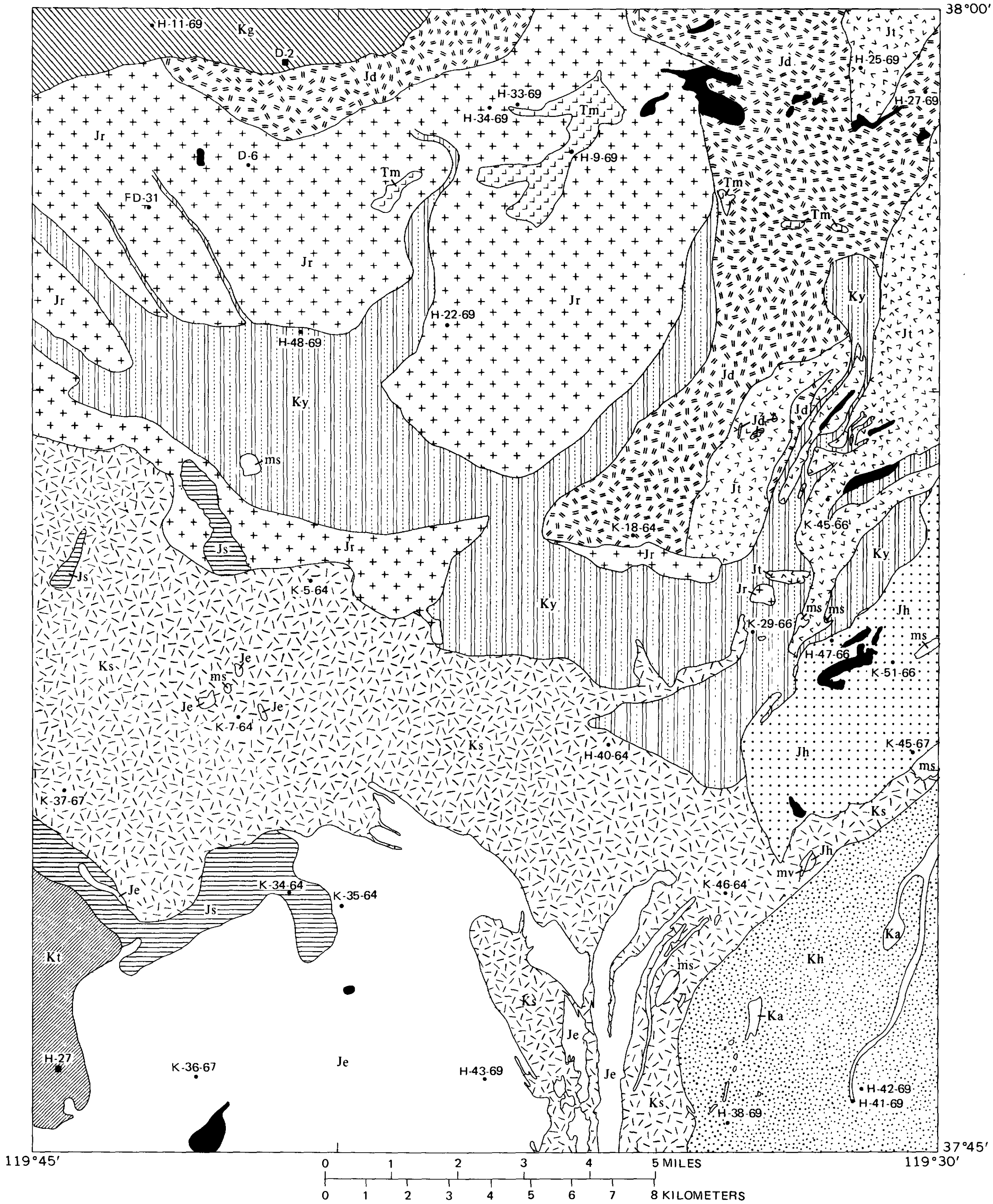

FIGURE 1.—Simplified bedrock geology of the Hetch Hetchy 15-minute quadrangle and locations of chemically analyzed samples and samples dated by potassium-argon methods.

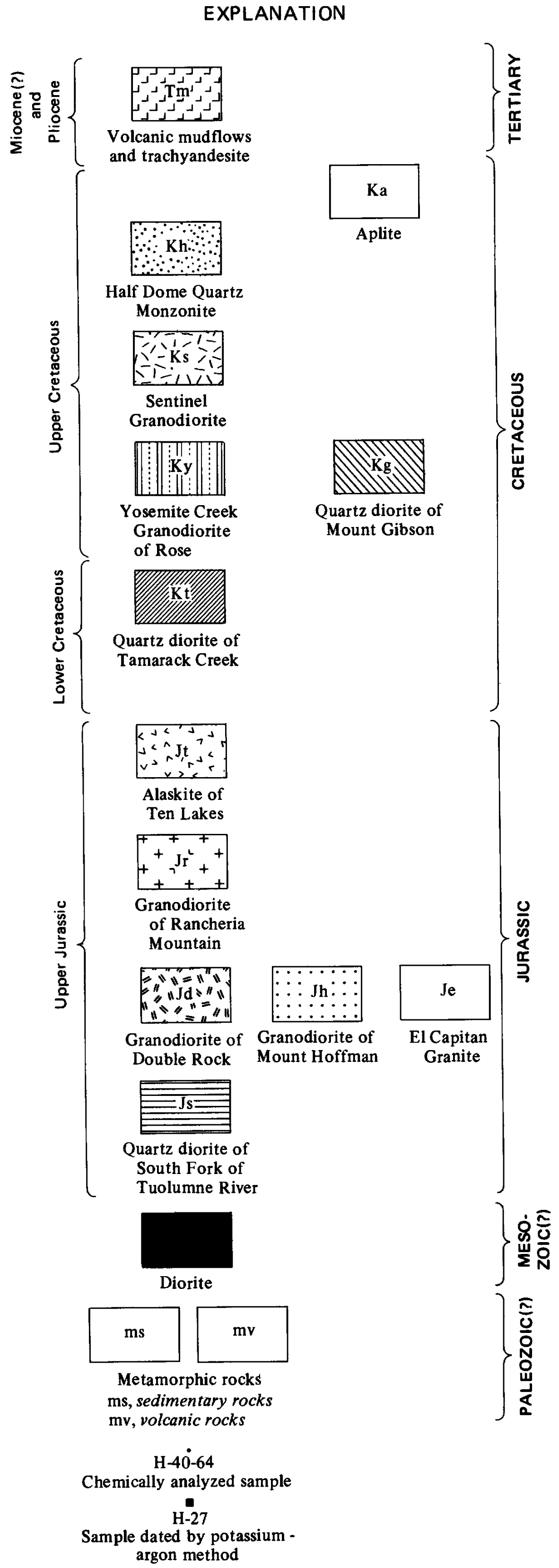

FIGURE 1.—Continued

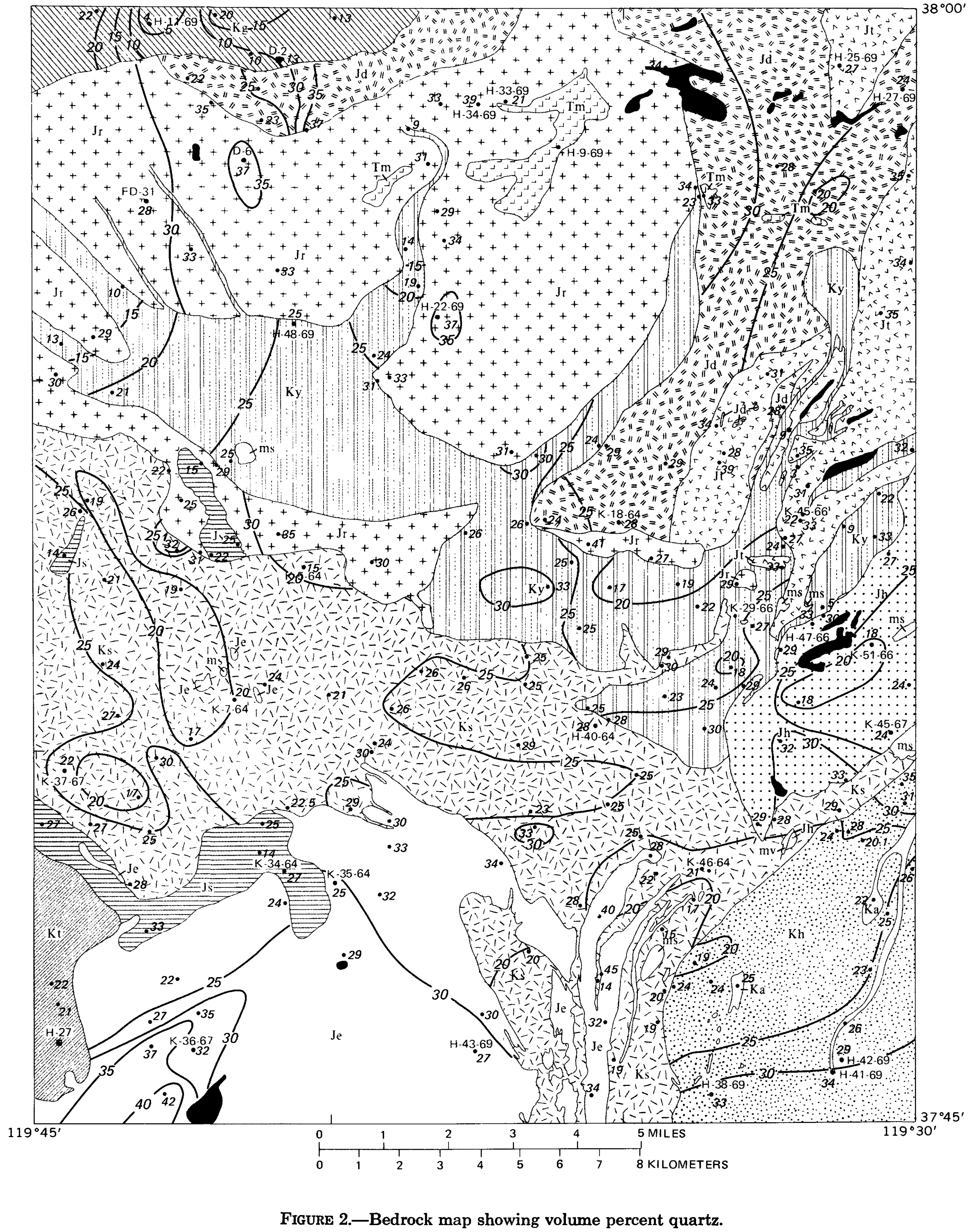

FIGURE 2.—Bedrock map showing volume percent quartz.

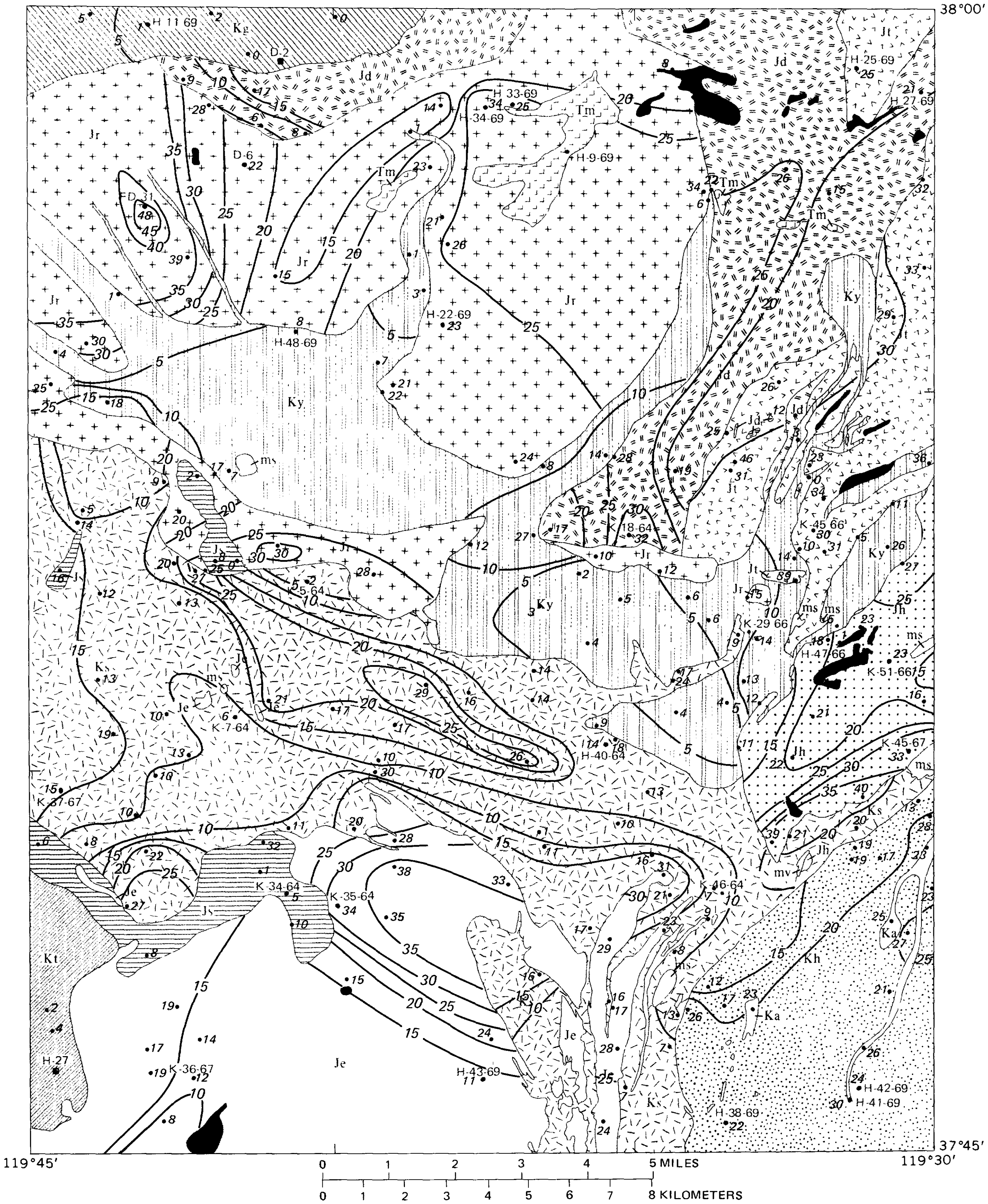

Figure 3.—Bedrock map showing volume percent potassium feldspar.

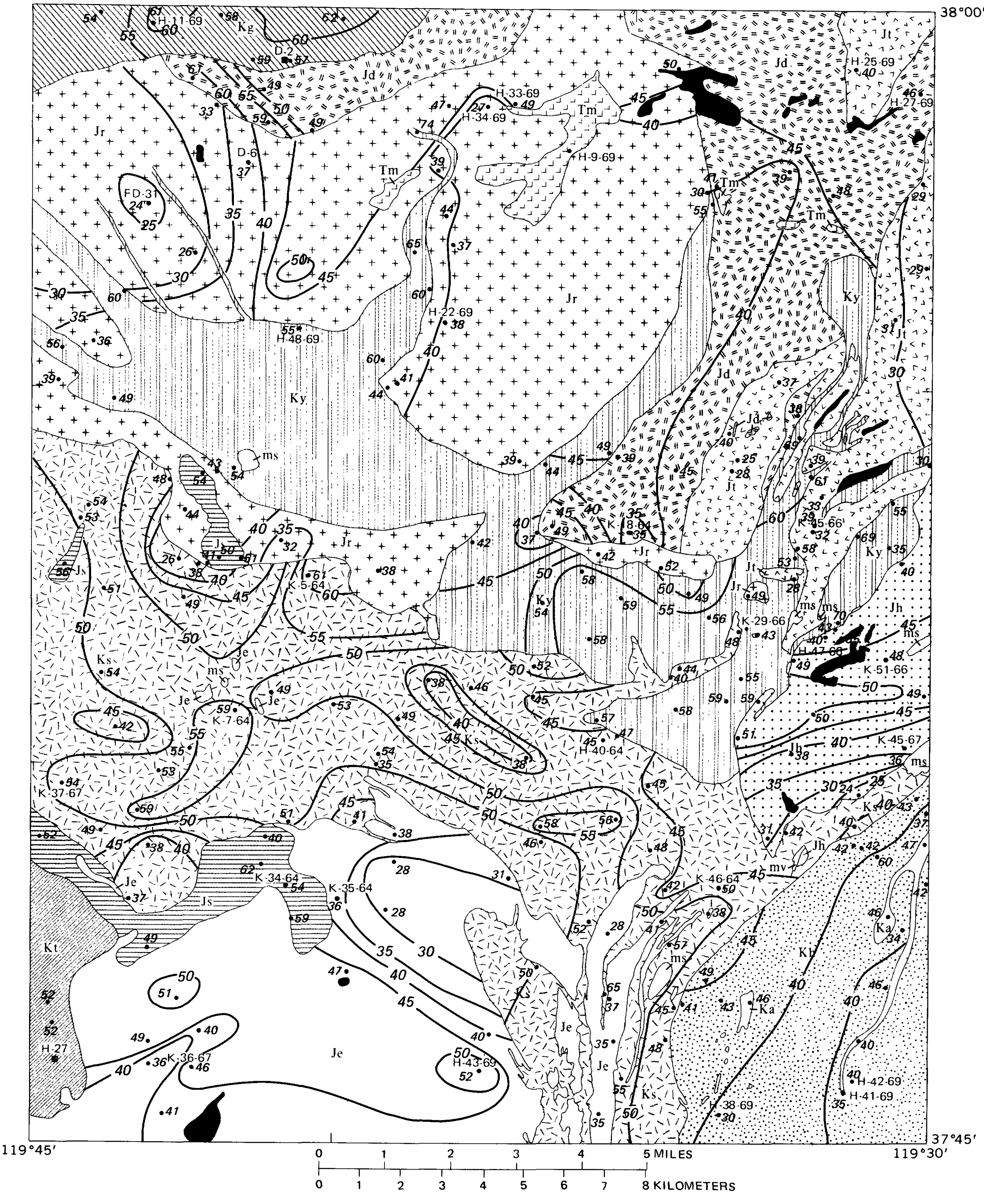

FIGURE 4.—Bedrock map showing volume percent plagioclase.

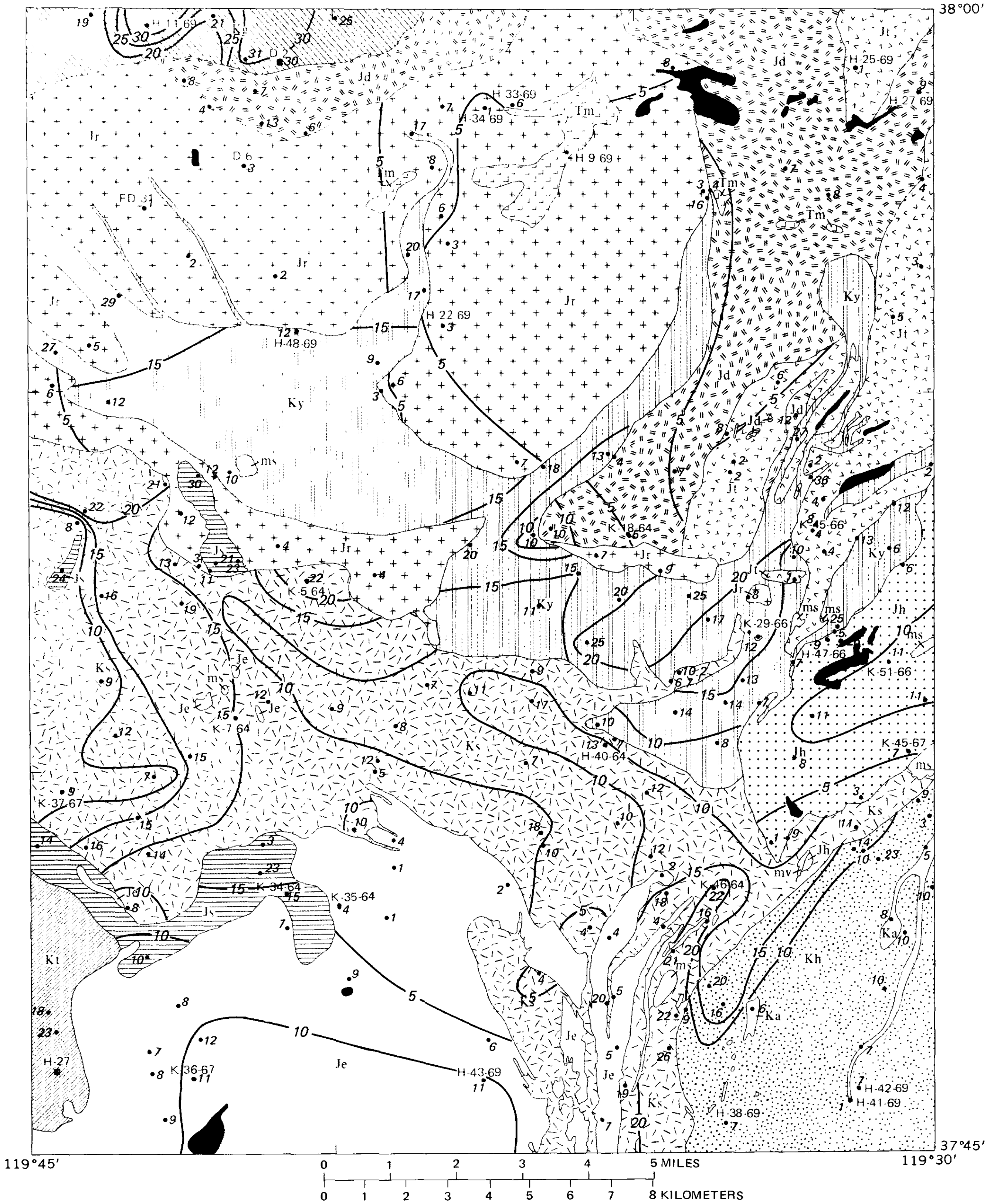

Figure 5.—Bedrock map showing volume percent mafic minerals.

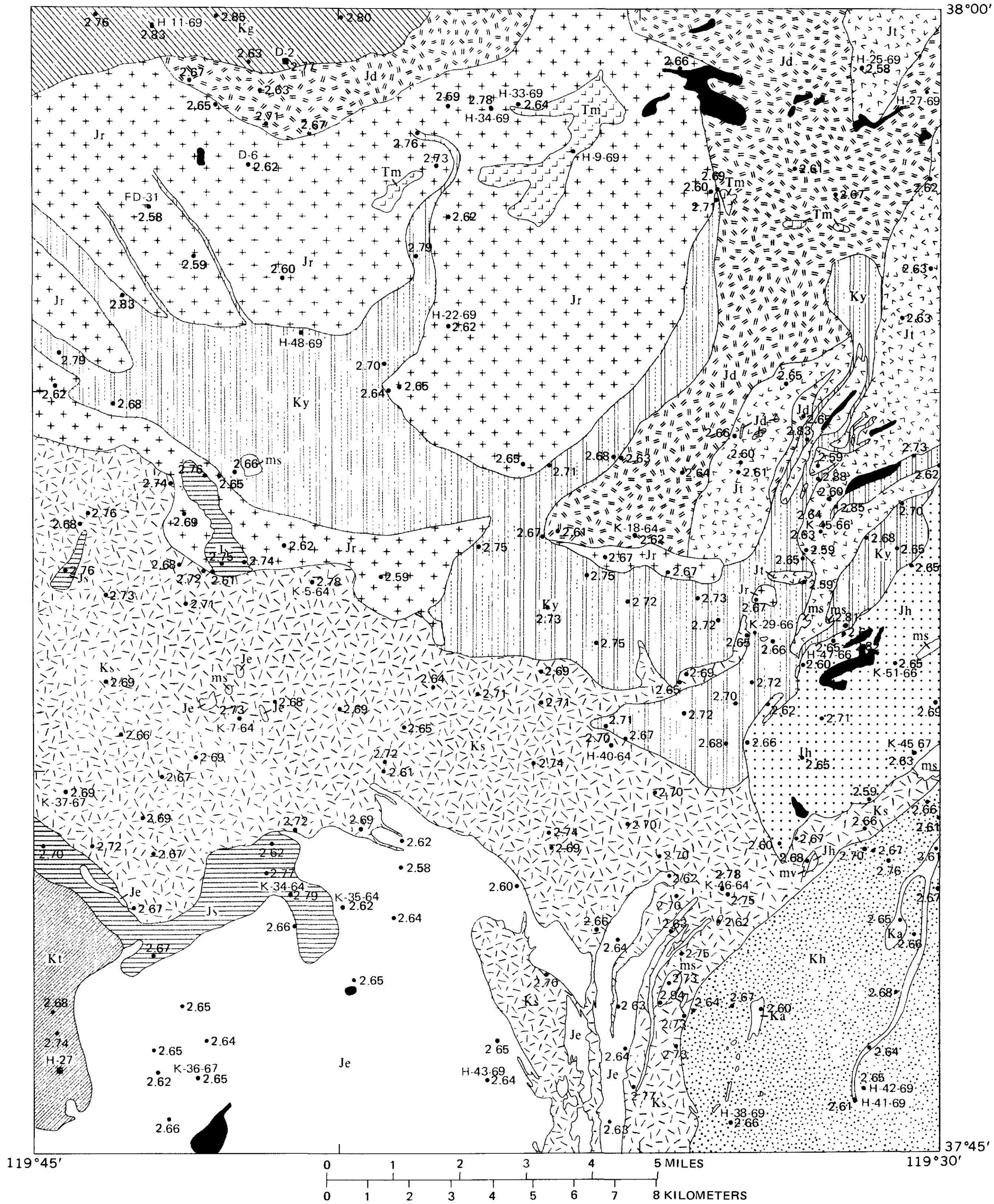

FIGURE 6.—Bedrock map showing specific gravity.

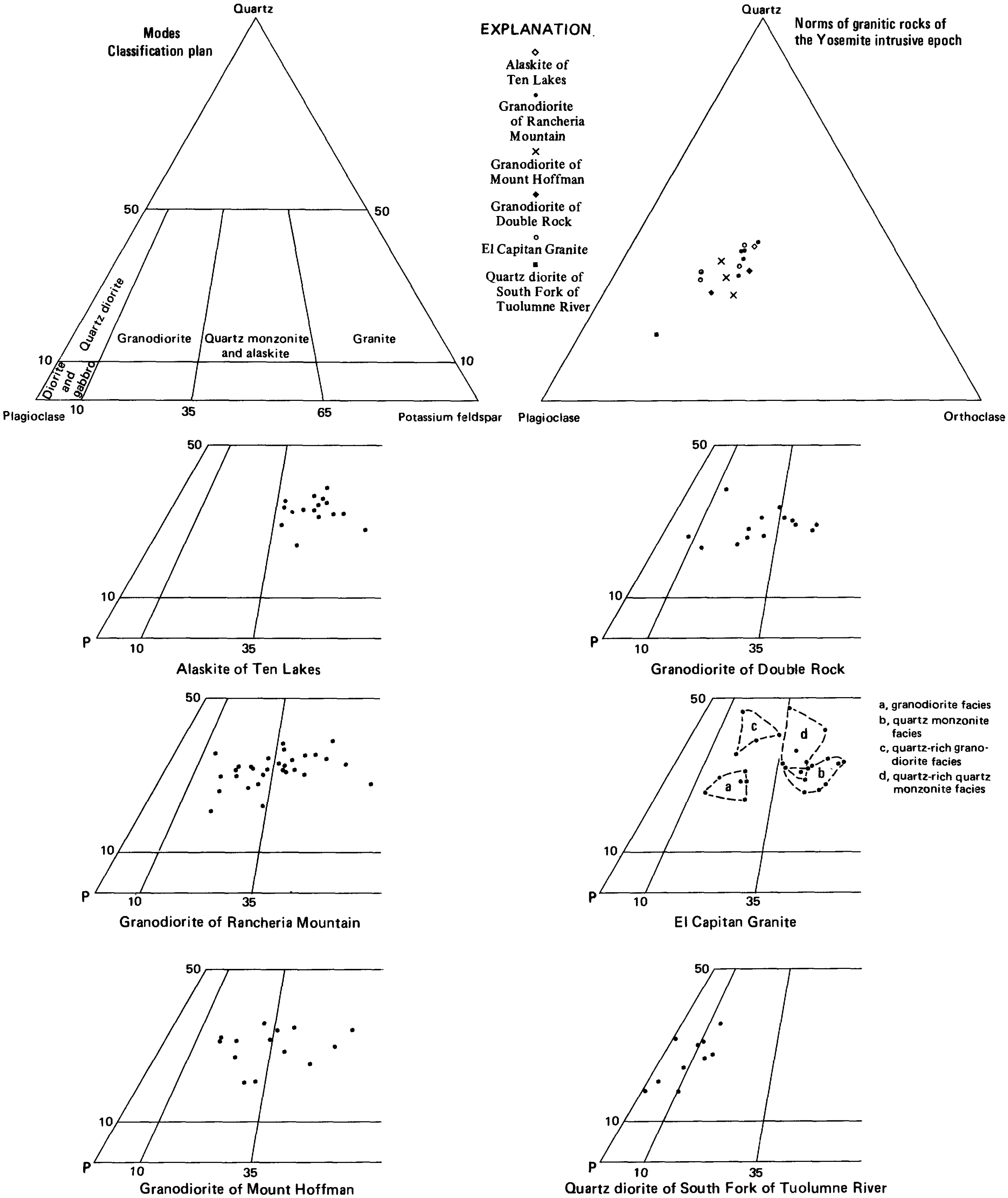

FIGURE 7.—Modes and norms of granitic and volcanic rocks. (Figure continued on following page.)

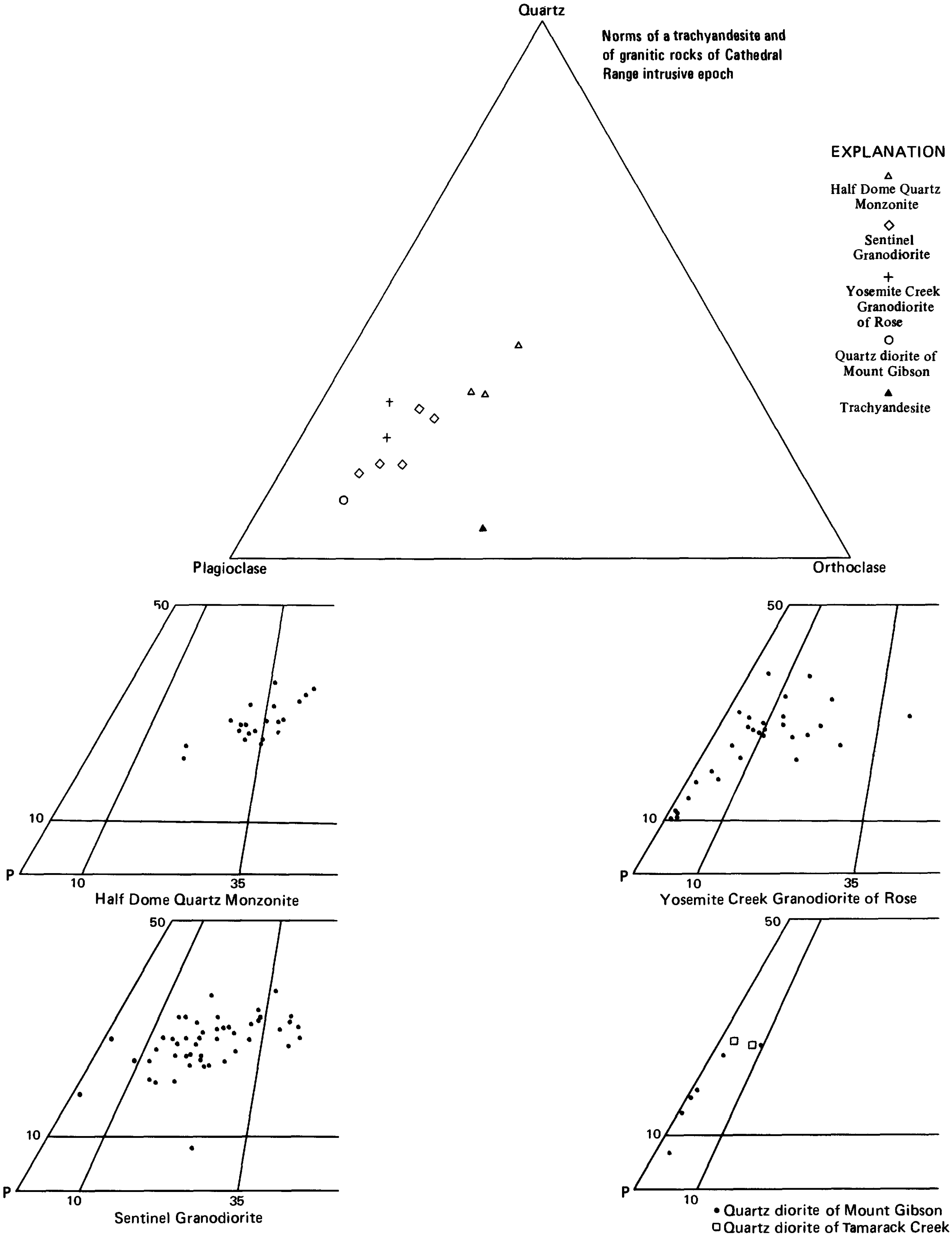

FIGURE 7.—Continued.

TABLE 1.—*Chemical and spectrographic analyses and norms*

[Chemical analyses by P. L. D. Elmore, Gillison Chloe, Hezekiah Smith, J. L. Kelsey, and James Glenn. Semiquantitative spectrographic analysis by Chris Heropoulos. Results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc., but are reported arbitrarily as midpoints of these brackets: 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of a reported value is approximately plus or minus one bracket at 68 percent confidence. Looked for but not found: Ag, As, Au, Bi, Cd, Ge, Hf, Ln, Nd, Pd, Pt, Re, Sb, Ta, Te, Th, Tl, U, W, Zn]

	Quartz diorite of South Fork Tuolumne River	El Capitan Granite			Granodiorite of Double Rock		Granodiorite of Mount Hoffman		
	K-34-64	K-43-69	K-36-67	K-35-64	K-18-64	H-27-69	H-47-66	K-51-66	K-45-66
Chemical analyses (weight percent)									
SiO_2	59.0	69.8	70.1	73.1	71.8	70.3	72.0	68.2	72.8
Al_2O_3	17.3	14.9	14.8	14.3	14.2	14.8	14.6	15.8	14.7
Fe_2O_3	2.2	1.1	.81	1.0	.94	.70	.94	1.1	.50
FeO	4.0	2.1	1.9	.92	1.6	2.0	1.6	2.1	1.0
MgO	3.0	.89	.78	.50	.59	.78	.69	.94	.47
CaO	6.2	2.7	2.6	1.4	1.7	2.0	2.2	2.7	1.8
Na_2O	3.0	3.5	3.7	3.4	3.0	4.0	3.2	3.1	3.7
K_2O	2.4	3.0	3.0	4.2	4.7	3.8	3.5	4.5	4.1
H_2O^+	1.0	.77	1.2	.61	.67	1.0	.62	.65	.50
H_2O^-	.23	.17	.14	.12	.14	.10	.09	.13	.07
TiO_2	.80	.39	.35	.32	.33	.34	.38	.45	.25
P_2O_5	.20	.14	.12	.11	.08	.10	.04	.13	.06
MnO	.09	.04	.06	.03	.03	.07	.04	.06	.06
CO_2	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Sum	99	100	100	100	100	100	100	100	100
Semiquantitative spectrographic analyses (parts per million)									
B	...	...	...	...	...	...	...	...	...
Ba	700	700	2,000	700	700	700	1,000	1,500	500
Be	...	...	...	5	5	2	...	...	3
Ce	...	100	150	...	...	100	100	...	...
Co	15	5	3	2	2	2	2	5	...
Cr	20	5	3	...	...	2	3	2	...
Cu	30	...	1	.7	.7	.7	2	2	1.5
Ga	20	15	20	20	15	20	15	15	20
La	...	50	70	...	...	50	30	...	...
Nb	...	...	...	7	...	15	...	...	15
Mo	...	...	...	...	...	...	...	...	...
Ni	10	...	...	...	...	...	...	...	...
Pb	...	15	20	10	30	10	15	20	20
Sc	20	3	5	5	7	7	5	7	5
Sn	...	...	...	...	...	...	...	...	15
Sr	700	300	500	300	150	200	300	300	150
V	150	30	30	20	15	20	30	30	10
Y	20	10	10	10	15	30	10	10	30
Yb	2	1.5	1	1.5	1	3	1.5	...	.7
Zr	100	150	150	100	70	100	70	100	70
CIPW norms (weight percent)									
Q	13.87	30.31	29.76	33.63	31.37	26.12	33.66	25.11	30.69
C	...	1.33	1.03	1.88	1.28	.71	1.65	1.23	1.05
or	14.27	17.82	17.81	24.82	27.84	22.46	20.70	26.63	24.23
ab	25.53	29.77	31.45	28.77	25.44	33.85	27.11	26.27	31.31
an	26.81	12.54	12.17	6.23	7.93	9.27	10.66	12.56	8.54
ne	...	...	...	...	...	...	...	...	...
wo	1.18	...	...	...	...	...	...	...	...
en	7.52	2.23	1.95	1.25	1.47	1.94	1.72	2.34	1.17
fs	4.40	2.39	2.36	.39	1.68	2.66	1.61	2.32	1.12
mt	3.21	1.60	1.18	1.45	1.37	1.02	1.36	1.60	.73
hm	...	...	...	...	...	...	...	...	...
il	1.53	.74	.67	.61	.63	.65	.72	.86	.48
ap	.48	.33	.29	.26	.19	.24	.10	.31	.14

TABLE 1.—*Chemical and spectrographic analyses and norms*—Continued

	Granodiorite of Rancheria Mountain					Alaskite of Ten Lakes		Quartz diorite of Gibson Mountains	Quartz diorite of Yosemite Creek of Rose	
	H–22–69	H–33–69	H–34–69	D–6	FD–31	K–45–67	H–25–69	H–11–69	K–29–66	H–48–69
Chemical analyses (weight percent)—Continued										
SiO_2	74.2	69.0	76.6	74.9	77.4	76.9	75.0	55.6	62.0	65.2
Al_2O_3	14.0	16.5	12.9	13.5	12.2	12.7	14.4	17.2	16.1	17.3
Fe_2O_3	.40	.84	.29	.28	.51	.15	.64	2.1	2.2	1.7
FeO	1.0	1.6	.55	.84	.45	.76	.60	5.8	3.4	2.5
MgO	.35	.65	.09	.33	.16	.09	.06	4.4	2.5	1.8
CaO	1.7	2.4	.89	1.5	.63	.82	.73	7.7	5.4	4.4
Na_2O	3.1	3.7	3.7	3.0	3.66	3.4	3.1	3.0	3.4	3.6
K_2O	4.1	3.8	4.3	4.2	4.49	4.1	4.5	1.6	2.0	1.7
H_2O^+	.54	.78	.00	.48	.00	.58	.71	.80	1.7	.75
H_2O^-	.11	.08	.04	.18	.00	.14	.10	.18	.13	.09
TiO_2	.15	.32	.07	.12	.12	.08	.10	1.2	.87	.63
P_2O_5	.04	.13	.02	.05	.02	.05	.00	.13	.20	.26
MnO	.04	.06	.06	.03	.06	.05	.00	.10	.07	.06
CO_2	<.05	<.05	.03	<.05	.03	<.05	<.05	<.05	<.05	<.05
Sum	100	100	99.5	99	99.7	100	100	100	100	100
Semiquantitative spectrographic analyses (parts per million)—Continued										
B	...	...	...	...	...	...	10	20	...	...
Ba	1,000	1,500	1,500	1,500	1,000	700	700	500	700	1,500
Be	1.5	2	...	...	2	3	...	...	...	...
Ce	100	...	...	...	...	...	...	...	...	100
Co	2	...	...	2	...	...	...	20	15	7
Cr	...	...	...	...	...	...	...	70	10	10
Cu	.7	1.7	1.5	1.7	1.5	.7	2	70	15	7
Ga	20	20	20	20	20	20	15	20	30	20
La	50	...	...	...	...	...	30	...	...	50
Nb	...	...	...	...	...	...	...	...	...	...
Mo	...	...	...	...	...	...	...	...	...	...
Ni	...	...	...	...	...	...	...	30	7	3
Pb	30	15	20	30	20	50	20	10	15	20
Sc	3	7	...	...	...	...	5	20	15	10
Sn	...	...	...	...	...	...	...	...	...	...
Sr	300	500	300	300	200	100	70	700	700	700
V	10	20	10	10	10	...	...	150	150	70
Y	10	...	...	...	...	10	15	15	20	15
Yb	1	1	...	...	...	1	1	2	2	1
Zr	70	150	70	100	70	50	70	70	70	100
CIPW norms (weight percent)—Continued										
Q	35.92	26.40	36.30	37.50	37.56	39.19	38.01	7.97	19.01	25.35
C	1.48	2.25	.56	1.42	.12	1.30	3.10	...	...	2.16
or	24.29	22.49	25.50	24.97	25.05	24.27	26.61	9.47	11.82	10.05
ab	26.30	31.35	30.92	25.54	30.92	28.82	26.25	25.43	28.78	30.47
an	8.19	11.07	4.45	7.16	3.14	3.75	3.62	28.80	22.77	20.13
ne	...	...	...	...	...	...	...	...	...	...
wo	...	...	...	...	...	...	...	3.60	1.14	...
en	.87	1.62	1.06	.83	.21	.23	.15	10.98	6.23	4.48
fs	1.34	1.83	.20	1.18	.40	1.24	.24	7.13	3.12	2.26
mt	.58	1.22	...	.41	.74	.22	.98	3.05	3.19	2.47
hm	...	...	...	...	...	...	...	...	...	...
il	.29	.61	...	.23	.22	.15	.38	2.28	1.65	1.20
ap	.10	.31	...	.12	...	.12	...	.31	.47	.62

TABLE 1.—*Chemical and spectrographic analyses and norms*—Continued

	Sentinel Granodiorite				Half Dome Quartz Monzonite		Aplite	Trachyandesite
K-46-64	H-40-64	K-5-64	K-37-67	K-7-64	H-38-69	H-42-69	H-41-69	H-9-69
Chemical analyses (weight percent)—Continued								
61.0	66.5	58.5	67.8	61.1	70.8	70.4	76.5	55.0
16.4	15.6	18.0	17.2	17.5	14.4	14.5	13.3	16.8
2.1	1.5	2.2	1.6	2.3	1.2	1.5	.26	3.2
3.8	2.5	3.8	1.8	3.0	1.2	1.3	.40	4.1
2.9	1.7	3.0	1.3	2.1	.87	1.0	.16	4.1
5.4	4.2	6.5	4.2	5.2	2.9	2.8	1.4	6.5
3.4	3.4	3.3	3.6	3.8	3.4	3.2	3.0	3.5
2.6	3.0	1.8	2.6	2.2	3.7	4.1	4.4	3.4
1.0	.69	.90	.58	1.0	.59	.56	.44	.84
.12	.10	.20	.13	.16	.10	.06	.05	.46
.84	.63	1.0	.66	.82	.28	.36	.06	.44
.21	.16	.27	.18	.25	.09	.12	.02	.75
.06	.04	.09	.05	.07	.03	.04	.00	.09
<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
100	100	100	99	100	100	100	100	99
Semiquantitative spectrographic analyses (parts per million)—Continued								
...	...	...	...	...	...	...	15	100
700	700	700	1,000	1,000	500	700	200	1,500
...	...	...	...	...	...	...	2	3
...	100	...	...	...	...	...	...	150
15	10	15	7	10	5	5	...	20
20	15	30	5	10	3	2	...	150
50	7	15	5	20	3	7	5	100
20	20	20	20	20	15	10	15	20
...	50	...	...	...	...	...	...	70
...	...	...	...	...	...	...	...	15
...	...	...	...	...	...	...	...	5
10	7	20	...	5	...	...	...	70
10	15	10	10	...	30	30	50	20
20	7	15	5	10	3	3	...	20
...	...	...	...	...	...	...	...	...
700	700	1,000	1,000	1,000	500	500	150	1,000
150	70	100	70	100	50	50	...	200
15	10	15	10	10	...	...	...	20
2	.7	1.5	.7	1	.7	3	2	1
100	70	70	100	150	50	30	7	200
CIPW norms (weight percent)—Continued								
14.97	23.36	13.49	25.60	16.00	29.52	28.68	38.84	3.33
...	...	...	1.24	.01	...	...	1.11	...
15.39	17.72	10.68	15.11	13.07	21.96	24.24	26.00	20.26
28.82	28.76	28.05	29.95	32.32	28.90	27.09	25.39	29.86
21.85	18.44	29.11	19.33	24.29	13.16	13.10	6.82	20.25
...	...	...	...	...	...	...	...	...
1.51	.56	.63	...	...	.29	.01	...	3.06
7.24	4.23	7.51	3.18	5.26	2.18	2.49	.40	10.30
3.97	2.39	3.69	.97	2.40	.81	.63	.42	4.36
3.05	2.17	3.20	2.28	3.35	1.75	2.18	.38	4.68
...	...	...	...	...	...	...	...	...
1.60	1.20	1.91	1.23	1.57	.53	.68	.11	.84
.50	.38	.64	.42	.60	.21	.28	.05	1.79

TABLE 2.—*Potassium-argon gases*

[Constants used K^{40}: $\gamma\varepsilon=0.584\times10^{-10}$ year^{-1}, $\gamma\beta=4.72\times10^{-10}$ year^{-1}; isotopic abundance 1.19×10^{-4} moles K^{40} per mole K. Radiogenic argon=rAr^{40}; total argon=tAr^{40}. Analysts: Lois Schlocker and R. W. Kistler]

Specimen	Rock name	Mineral dated	K_2O (weight percent)	rAr^{40} (moles per g $\times 10^{-11}$)	rAr^{40}/tAr^{40} (percent)	Age (m.y.)
D-2	Quartz diorite of Mount Gibson.	Biotite	8.70	109.77	91	83.7 ± 1.6
		Hornblende	.725	8.95	73	81.9 ± 2.0
H-27	Quartz diorite of Tamarack Creek.	Biotite	9.40	126.82	92	89.4 ± 1.5
		Hornblende	.847	12.30	80	95.9 ± 2.2

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